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(54) **MULTIPLE NETWORK CONNECTIONS FROM A SINGLE PPP LINK WITH NETWORK ADDRESS TRANSLATION**

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(52) **U.S. Cl.** **370/401**; 709/227
(58) **Field of Search** 370/389, 400, 370/401, 402, 352, 353, 354; 709/227, 217, 218, 219

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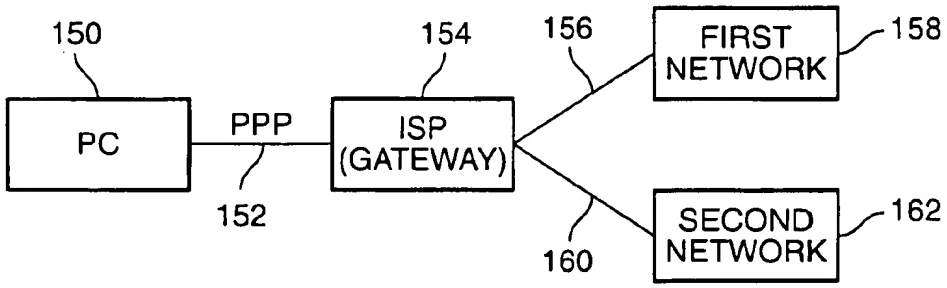
(57) **ABSTRACT**

Multiple simultaneous network connections from a single PPP connection may be accomplished by utilizing a gateway in the following manner. A first network connection is established between the gateway and a first network. A first real network address for the user is then received, the first real network address assigned by the first network. Then, the gateway may establish a network session between the gateway and a second network and receive a second real network address for the user, the second real network address assigned by the second network. A virtual network address may be assigned to the user for network address translation purposes. Additional network connections may be added in a similar manner. Network address translation is then performed on packets traveling between the user and any of the network sessions. This allows each of the simultaneous network connections to gain the benefits of network address translation.

93 Claims, 5 Drawing Sheets



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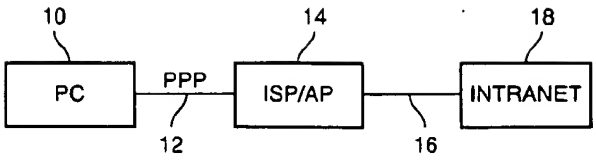


FIG. 1

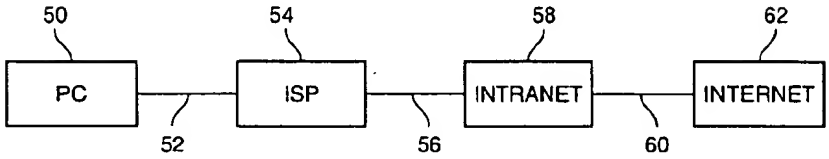


FIG. 2

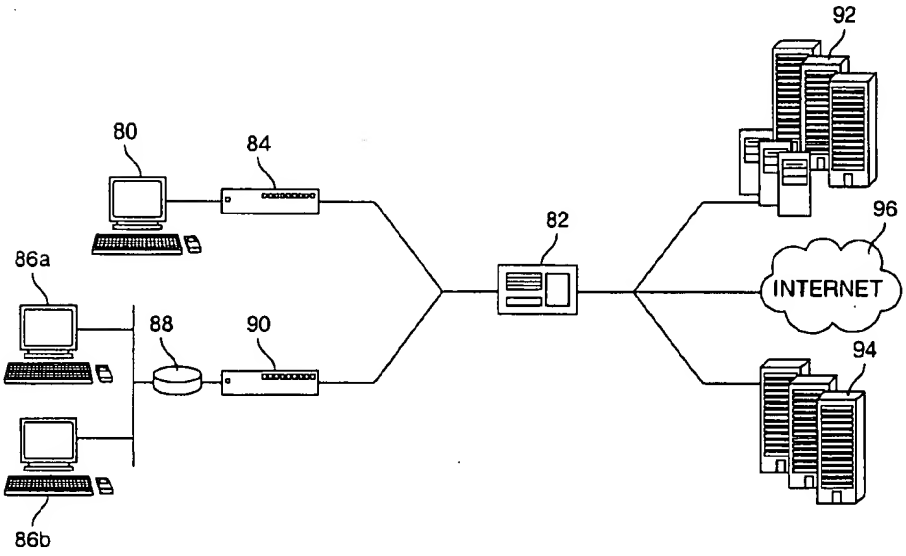


FIG. 3

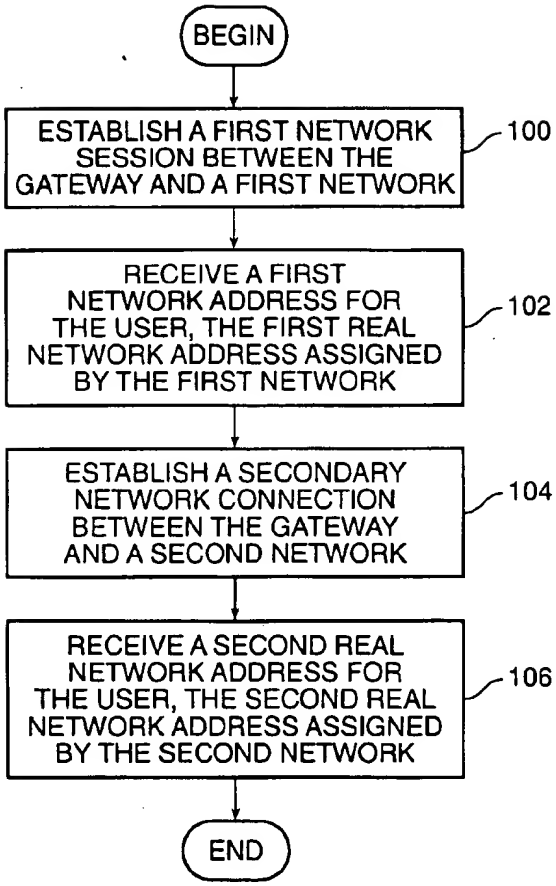

BEGIN
ESTABLISH A FIRST NETWORK SESSION BETWEEN THE GATEWAY AND A FIRST NETWORK
100
RECEIVE A FIRST NETWORK ADDRESS FOR THE USER, THE FIRST REAL NETWORK ADDRESS ASSIGNED BY THE FIRST NETWORK
102
ESTABLISH A SECONDARY NETWORK CONNECTION BETWEEN THE GATEWAY AND A SECOND NETWORK
104
RECEIVE A SECOND REAL NETWORK ADDRESS FOR THE USER, THE SECOND REAL NETWORK ADDRESS ASSIGNED BY THE SECOND NETWORK
106
END

FIG. 4

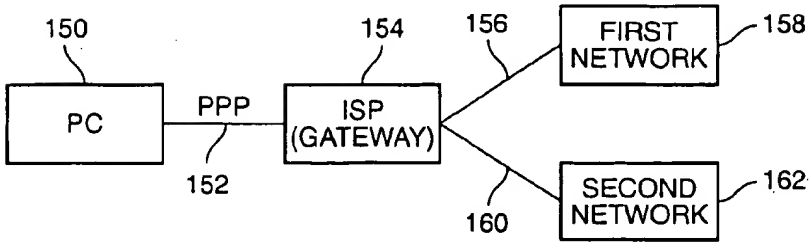

150
PC
PPP
152
154
ISP (GATEWAY)
156
FIRST NETWORK
158
SECOND NETWORK
160
162

FIG. 5

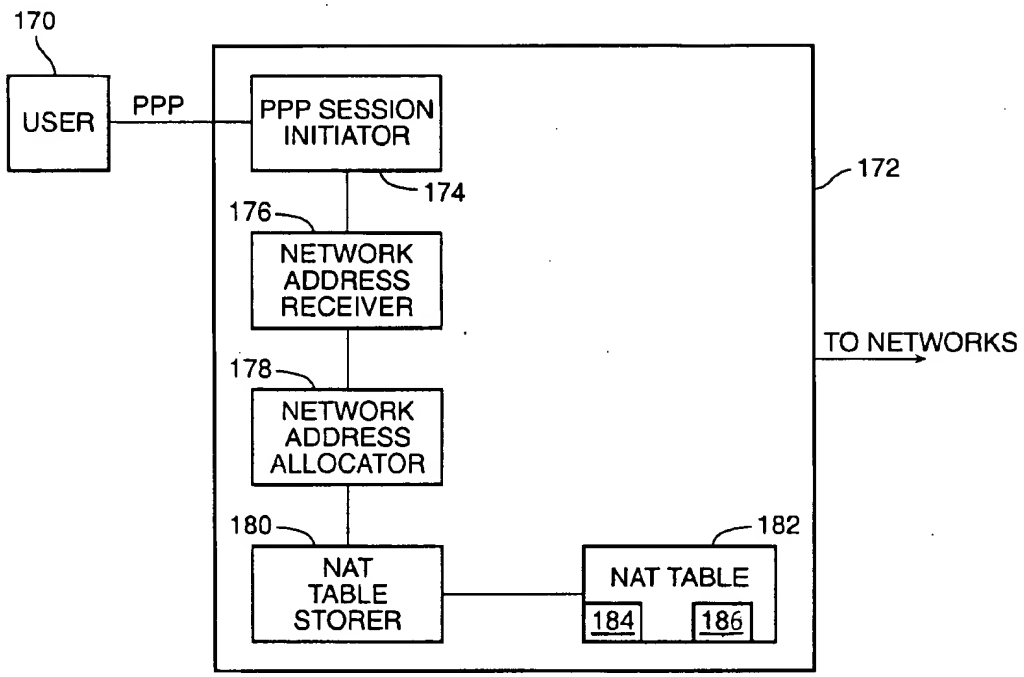

170
USER
PPP
PPP SESSION INITIATOR
174
172
176
NETWORK ADDRESS RECEIVER
TO NETWORKS
178
NETWORK ADDRESS ALLOCATOR
180
182
NAT TABLE STORER
NAT TABLE
184
186

FIG. 6

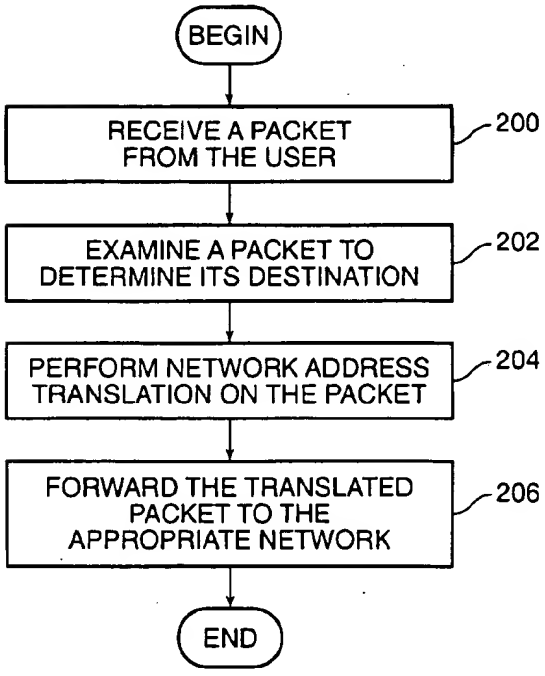

BEGIN
RECEIVE A PACKET FROM THE USER
200
EXAMINE A PACKET TO DETERMINE ITS DESTINATION
202
PERFORM NETWORK ADDRESS TRANSLATION ON THE PACKET
204
FORWARD THE TRANSLATED PACKET TO THE APPROPRIATE NETWORK
206
END

FIG. 7

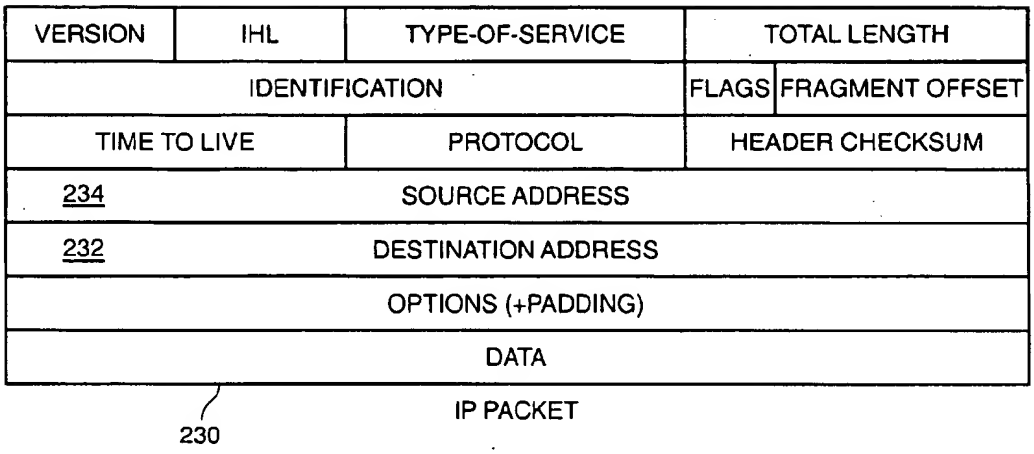

VERSION
IHL
TYPE-OF-SERVICE
TOTAL LENGTH
IDENTIFICATION
FLAGS
FRAGMENT OFFSET
TIME TO LIVE
PROTOCOL
HEADER CHECKSUM
234
SOURCE ADDRESS
232
DESTINATION ADDRESS
OPTIONS (+PADDING)
DATA
IP PACKET
230

FIG. 8

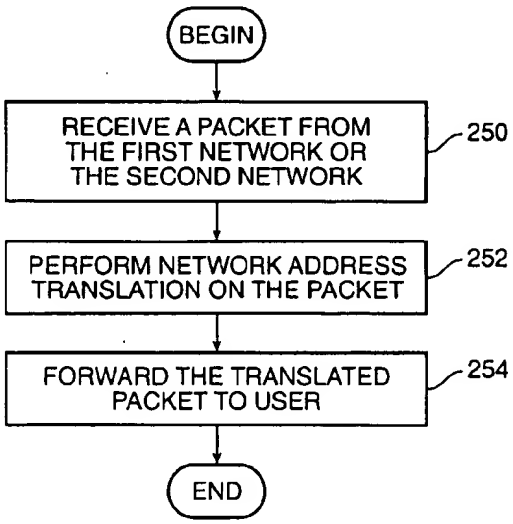

BEGIN
RECEIVE A PACKET FROM THE FIRST NETWORK OR THE SECOND NETWORK
250
PERFORM NETWORK ADDRESS TRANSLATION ON THE PACKET
252
FORWARD THE TRANSLATED PACKET TO USER
254
END

FIG. 9

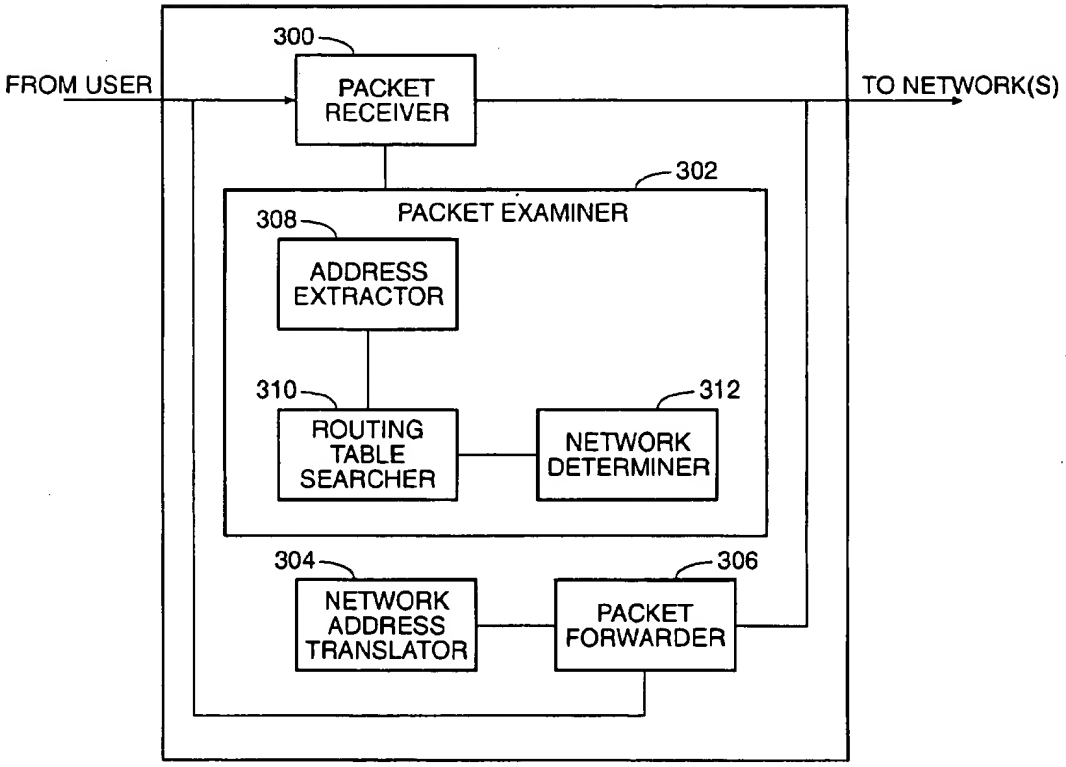

300
FROM USER
PACKET RECEIVER
TO NETWORK(S)
302
PACKET EXAMINER
308
ADDRESS EXTRACTOR
310
ROUTING TABLE SEARCHER
312
NETWORK DETERMINER
304
NETWORK ADDRESS TRANSLATOR
306
PACKET FORWARDER

FIG. 10

MULTIPLE NETWORK CONNECTIONS FROM A SINGLE PPP LINK WITH NETWORK ADDRESS TRANSLATION

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to the field of computer networks. More particularly, the present invention relates to managing multiple network connections from a single PPP link while performing network address translation.

2. The Background

The Point-to-Point protocol (PPP) is a data link protocol that provides dial up access over analog or digital transmission lines. PPP provides many advanced features, including error detection, support of multiple protocols, negotiation of IP addresses at connection time, and authentication. There are three main features of PPP. The first is that it provides a framing method to delineate the end of one frame and the beginning of the next one, in order to handle error detection. The second is a link control protocol for bringing lines up, testing them, negotiating options, and bringing them down again when they are no longer needed. This is known as the Link Control Protocol (LCP). The third is a way to negotiate network layer options in a way independent of the network layer protocol to be used. Thus, the method chosen may have a different Network Control Protocol (NCP) for each network layer supported.

PPP is commonly used as the data link protocol between a user and an Internet Service Provider (ISP) or access point. This is usually accomplished through the following method. The personal computer of the user is instructed to call the ISP through a modem. After the ISP's modem receives the call and establishes a physical connection, the personal computer sends a series of LCP packets in the payload field of one or more PPP frames. These packets, and their responses, comprise the negotiation of the session, and set the PPP parameters to be used during the session.

Once the negotiation is complete, a series of NCP packets are sent to configure the network layer. Typically, the personal computer wants to run a TCP/IP protocol stack, so it needs an IP address. The NCP for IP may then be used to assign an IP address to the user (dynamic assignment of IP addresses is now common for dial-up users). At this point, the personal computer has become an Internet host and may send and receive IP packets, just as a hardwired host could. When the user has finished, NCP is used to tear down the network layer connection and free the IP address. The LCP is then used to shut down the data link layer connection. Finally, the personal computer hangs up the modem, releasing the physical layer connection.

There are currently eleven types of LCP packets. These types are illustrated in Table 1 below, along with the direction in which they travel (from Initiator (I) to responder (R) or vice-versa) and their description.

In recent years, "intranets" have been rising in popularity, especially with large companies. An intranet is an internal network that serves only a specific type of person (such as employees of a corporation, or students at a school). The intranet is usually not accessible to the general public. Intranets have become popular mainly because they allow for much more productive communication between users within the network,

TABLE 1

Name	Direction	Description
Configure-request	I → R	List of proposed options and values
Configure-ack	I ← R	All options are accepted
Configure-nak	I ← R	Some options are not accepted
Configure-reject	I ← R	Some options are not negotiable
Terminate-request	I → R	Request to shut down the line
Terminate-ack	I ← R	OK to shut down the line
Code-reject	I ← R	Unknown request received
Protocol-reject	I ← R	Unknown protocol received
Echo-request	I → R	Please send this frame back
Echo-reply	I ← R	Here is the frame back
Discard-request	I → R	Discard this frame (for testing)

even when the users are dispersed over a wide geographic area (such as in multi-national corporations).

FIG. **1** is a block diagram depicting the typical connection to an intranet. Personal computer **10** connects through a link **12** to an Internet service provider (ISP) or access point (AP)**14**. The ISP or AP **14** then connects through link **16** to the Intranet **18**.

Many entities that maintain intranets, however, have also wanted to offer users access to the Internet or to other intranets as well. There were, however, a limited number of ways that this could be accomplished. The first, and most simple, way would be for the user to first terminate the existing PPP connection between the PC **10** and the ISP or access point **24**. Then the user could log into a second intranet or to the Internet. The major drawbacks of this solution are obvious. It does not allow for simultaneous connection to two intranets, or to one intranet and the Internet, thus limiting the productivity of the user. Additionally, it requires termination of the PPP link between the PC and the ISP, thus using up valuable time on the user's end, as he has to re-initiate a connection process.

The second way an entity could offer access to a second intranet or to the Internet is to have a preconfigured connection from the intranet to the second intranet or Internet, such that communications between the user and the second intranet or Internet pass through the intranet. FIG. **2** is a block diagram illustrating a connection to the Internet **62** through an intranet **58**. A user at PC **50** maintains a PPP connection **52** to ISP **54**, which is connected to the intranet **58**. Intranet **58** is then connected through link **60** to the Internet **62**. The drawback of this solution is that the traffic from the user at PC **50** to the Internet **62** passes through the intranet **58**. This increases the traffic traveling through the intranet **58** and poses a security risk to the information sent via the intranet **58**.

One major drawback of PPP, therefore, is that it is designed as a point to point protocol, meaning that it is designed for use between two endpoints. Therefore, it is currently not possible for a user to connect to two independent endpoints simultaneously (such as an intranet and the Internet, or to two independent intranets) using a single PPP link.

What is needed is a method by which a user may connect to two independent endpoints simultaneously using a single PPP link.

SUMMARY OF THE INVENTION

Multiple simultaneous network connections from a single PPP connection may be accomplished by utilizing a gateway in the following manner. A first network connection is established between the gateway and a first network. A first real network address for the user is then received, the first

real network address assigned by the first network. Then, the gateway may establish a network session between the gateway and a second network and receive a second real network address for the user, the second real network address assigned by the second network. A virtual network address may be assigned to the user for network address translation purposes. Additional network connections may be added in a similar manner. Network address translation is then performed on packets traveling between the user and any of the network sessions. This allows each of the simultaneous network connections to gain the benefits of network address translation.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a block diagram depicting a typical connection to an intranet.

FIG. **2** is a block diagram illustrating a connection to the Internet through an intranet.

FIG. **3** is a diagram illustrating the use of a gateway to couple multiple networks in accordance with a presently preferred embodiment of the present invention.

FIG. **4** is a flow diagram illustrating a method for establishing multiple network connections for a user having a PPP connection to a gateway according to presently preferred embodiment of the present invention.

FIG. **5** is a block diagram illustrating multiple network connections from a single PPP connection as they would appear after the steps depicted in FIG. **4** were executed in accordance with a presently preferred embodiment of the present invention.

FIG. **6** is a block diagram illustrating a network gateway for use in a system having a user with a PPP connection to a gateway in accordance with a presently preferred embodiment of the present invention.

FIG. **7** is a flow diagram illustrating a method for outgoing communications routing in a system in which a user is connected to a first network and a second network according to a presently preferred embodiment of the present invention.

FIG. **8** is a diagram illustrating a packet in accordance with the IP protocol.

FIG. **9** is a flow diagram illustrating a method for incoming communications routing of in a system in which a user is connected to a first network and a second network according to a presently preferred embodiment of the present invention.

FIG. **10** is a block diagram illustrating a network gateway according to another embodiment of the present invention.

DETAILED DESCRIPTION OF A PREFERRED EMBODIMENT

Those of ordinary skill in the art will realize that the following description of the present invention is illustrative only and not in any way limiting. Other embodiments of the invention will readily suggest themselves to such skilled persons.

In accordance with a presently preferred embodiment of the present invention, the components, process steps, and/or data structures are implemented using a gateway device. Different implementations may be used and may include other types of operating systems, computing platforms, computer programs, and/or general purpose machines. In addition, those of ordinary skill in the art will readily recognize that devices of a less general purpose nature, such as hardwired devices, devices relying on FPGA or ASIC technology, or the like, may also be used without departing from the scope and spirit of the inventive concepts disclosed herewith.

A method for making multiple network connections with network address translation is provided. This method may be executed by a gateway. A gateway is a device which performs protocol conversion between different types of networks or applications. The term gateway is not meant to be limited to a single type of device, as any device, hardware or software, that may act as a bridge between the user and the networks may be considered a gateway for purposes of this application. FIG. **3** is a diagram illustrating the use of a gateway to couple multiple networks. Computer **80** connects to gateway **82** through a modem **84**, while computers **86***a* and **86***b* couple to a hub **88**, then through modem **90** to gateway **82**. Gateway **82** may then interface computers **80**, **86***a*, and **86***b* to multiple networks. These may include a first corporate intranet **92**, a second corporate intranet **94**, and the Internet **96**.

In the present invention, network address translation (NAT) is utilized on all the network connections. NAT is an Internet standard that enables a local-area network (LAN), intranet, or ISP to use one set of network addresses for internal traffic and a separate set of network addresses for external traffic. Network addresses are generally Internet Protocol (IP) addresses, but there are many other possible network addresses as well. At the ISP level, there is normally a gateway, which is a device that acts as an interface between the ISP and the intranet or Internet. When network address translation is used, the Gateway will act to convert the destination addresses of incoming packets and source addresses of outgoing packets so that traffic is directed to the correct address.

Network address translation provides two main advantages. First, it adds security to the LAN or intranet, as it acts as a type of firewall, preventing users from outside the LAN or intranet from determining the internal network addressing scheme of the LAN or intranet. Second, it saves network addresses. With the ever growing popularity of the Internet and computer networks, a major issue is the availability of IP addresses. A standard IP address is 32 bytes in length, providing a total of 2^{32} possible IP addresses. Those of ordinary skill in the art will readily recognize that not all of these possible IP addresses are available due to administrative expediencies, such as reserving blocks of IP addresses for future use. Network address translation saves IP addresses by allowing the ISP to use IP addresses internally that may be used by other networks on the Internet because there is no possibility of conflict.

FIG. **4** is a flow diagram illustrating a method for establishing multiple network connections for a user having a PPP connection to a gateway according to presently preferred embodiment of the invention. This method may be executed by a gateway. At step **100**, a first network session is established between the user and the first network. The connection does not have to be PPP, but may be any other communications standard. At step **102**, a first real network address is received for the user. This first real network address is assigned by the first network.

At some point during the session, the user may request connection to a second network. Therefore, at step **104**, the gateway may establish a second network session between the gateway and a second network. At step **106**, a second real network address for the user is received, the second real network address assigned by the second network.

Network address translation will be utilized on each of the sessions. Therefore, this may or may not require an action to be taken by the gateway when the connection is established. Some forms of network address translation require that a NAT table be maintained. In such instances, the gateway may assign the user a virtual network address according to a network address translation allocation scheme and store the virtual network address in a NAT table in an entry corresponding to the real network address received from the network being connected. Some forms of network address translation involve simply applying the network address translation scheme to each packet as it is received. In such instances, no steps need to be taken by the gateway until a packet is received.

FIG. **5** is a block diagram illustrating multiple network connections from a single PPP connection as they would appear after the steps depicted in FIG. **4** were executed. PC **150** maintains the PPP connection to the ISP **154**, which may contain the gateway. First network session **156** links the gateway to the first network **158**, while second network connection **160** connects the gateway to the second network.

The gateway may configure more than two network sessions should the user so desire. These additional network sessions are created in a similar fashion to the other network sessions.

Additionally, "tunneling" may be utilized in the case where not all the links follow the same protocol, but the two endpoints follow the same protocol. Tunneling allows two hosts on the same type of network to communicate even though there may be different types of network in between. Tunneling is accomplished by encapsulating packets sent from a first type of network within packets of a type compatible with a second type of network for the duration of the packet's journey through the second type of network. Then, the outer packet is stripped off (and possibly some demultiplexing takes place) when the packet reaches the first type of network again. Layer Two Tunneling Protocol (L2TP) is a specific tunneling protocol that acts as an extension to the PPP protocol to allow ISPs to operate virtual private networks. L2TP or any other tunneling protocol may be used when establishing the network sessions.

FIG. **6** is a block diagram illustrating a network gateway for use in a system having a user with a PPP connection to the gateway. User **170** has a PPP connection to gateway **172**. The gateway **172** then contains many parts that interface the user **170** to multiple networks. A PPP session initiator **174** establishes a first PPP session between the gateway and a first network. A network address receiver **176** receives a first real network address for the user, the first real network address assigned by the first network. The PPP session initiator **174** further establishes a second PPP session between the gateway and a second network. The network address receiver further receives a second real network address for the use, the second real network address assigned by the second network.

A network address allocator **178** assigns the user a virtual network address. A NAT table storer **180** stores the virtual network address is a NAT table **182** in an entry **184** corresponding to the first real network address, and stores said virtual network address in the NAT table **180** in an entry **184** corresponding to the second real network address.

FIG. **7** is a flow diagram illustrating a method for outgoing communications routing in a system in which a user is connected to a first network and a second network according to a presently preferred embodiment of the invention.

At step **200**, a packet is received from the user. At step **202**, the packet is examined to determine if its destination is the first network or the second network. FIG. **8** is a diagram illustrating a packet in accordance with the IP protocol. Normally, there will be a destination network address field **232** within the packet **230**. The destination network address may then be extracted from this field. Then the address may be compared with a routing table. This routing table may be maintained by the gateway or a router. The routing table contains a list of addresses and the corresponding networks to which packets sent to that address should be routed. This allows the gateway to forward the packets to the correct network. In many cases, routing the packets to either network will allow the packet to arrive at its destination. In these cases, the routing table may indicate the network that will provide for the shortest travel time for the packet, in order to save the user some time. In yet other cases, it will not be clear to which network to send the packet (indicated by the fact that there is no entry for the address in the routing table). In these cases, a default network will be established to which to send packets.

Referring back to FIG. **7**, at step **2204**, network address translation is performed (perhaps by applying a network address translation mapping scheme to the packet or perhaps by looking up the destination real address in a NAT table) to arrive at a real destination address. At step **206**, the packet is then forwarded to the appropriate network. A similar scheme may be utilized when there are more than two simultaneous network connections, with NAT being performed on each network connection.

Likewise, when a packet is received from a network, then network address translation is performed. FIG. **9** is a flow diagram illustrating a method for incoming communications routing of in a system in which a user is connected to a first network and a second network. At step **250**, a packet is received from the first network or the second network. At step **252**, network address translation is performed on the packet. Then the packet is forwarded to the user at step **254**.

FIG. **10** is a block diagram illustrating a network gateway according to another embodiment of the present invention. The components of this gateway may be combined with the gateway depicted in FIG. **5** for use as one complete gateway. A packet receiver **300** receives a packet sent by the user. A packet examiner **302** examines the packet to determine if its destination is the first network or the second network. A network address translator **304** performs network address translation on the packet. A packet forwarder **306** forwards the translated packet to the first network or the second network, depending upon the packet's destination.

The packet examiner **302** may contain a network address extractor **308**, which extracts a destination network address from the packet, a routing table searcher **310**, which looks up the destination network address in a routing table, and a network determiner **312**, which determines that the destination is the first network or the second network based upon the listing for the destination network address in the routing table. The network determiner **312** may further determine that the destination is the first network or second network based upon a default setting if the destination network address is not listed in the routing table.

The packet receiver **300** may further receive a second packet, the second packet sent from said first network or said second network, The network address translator **304** may further perform network address translation on said second packet. The packet forwarder **306** may further forward said second packet to the user.

This invention allows for the simultaneous connection to two or more network s from only one single PPP connection.

It also allows for networks to be added at the time the user requests connection, such that the networks do not need to be preconfigured. All of the benefits of network address translation may be realized on each of the simultaneous network connections. Additionally, an increase in security is provided in that traffic to networks travel directly to the gateway rather than through one of the other simultaneously connected networks.

While embodiments and applications of this invention have been shown and described, it would be apparent to those skilled in the art that many more modifications than mentioned above are possible without departing from the inventive concepts herein. The invention, therefore, is not to be restricted except in the spirit of the appended claims.

What is claimed is:

1. A method for establishing multiple network connections for a user having a PPP connection to a gateway, including the steps of:

establishing a first network session between the gateway and said first network;

receiving a first real network address for the user, said first real network address assigned by said first network;

establishing a second network session between the gateway and a second network while said first network session is established; and

receiving a second real network address for the user, said second real network address assigned by said second network.

2. The method of claim 1, further including the steps of:

assigning the user a virtual network address; and

storing said virtual network address in a network address translation table in an entry corresponding to said first real network address; and

storing said virtual network address in a network address translation table in an entry corresponding to said second real network address.

3. The method of claim 2, wherein said assigning step includes the step of assigning the user a virtual network address utilizing a network address translation allocation scheme.

4. The method of claim 1, wherein said first network session and said second network session are tunneling sessions.

5. The method of claim 3, wherein said first network session and said second network session are L2TP sessions.

6. A method for establishing multiple network connections for a user having a PPP connection to a gateway, including the steps of:

receiving a first PPP connection request from the user;

negotiating LCP options between the user and a first network;

establishing a first PPP session between the gateway and said first network;

receiving a first real network address for the user, said first real network address assigned by said first network;

receiving a second PPP connection request from the user;

negotiating LCP options between the user and a second network;

establishing a second PPP session between the gateway and said second network while said first PPP session is established; and

receiving a second real network address for the user, said second real network address assigned by said second network.

7. The method of claim 6, further including the steps of:

assigning the user a virtual network address;

storing said virtual network address in a network address translation table in an entry corresponding to said first real network address; and

storing said virtual network address in a network address translation table in an entry corresponding to said first real network address.

8. The method of claim 7, wherein said assigning step includes the step of assigning the user a virtual network address utilizing a network address translation allocation scheme.

9. The method of claim 7, wherein said first network session and said second network session are tunneling sessions.

10. The method of claim 7, wherein said first network session and said second network session are L2TP sessions.

11. A method for network communications in a system having a user with a PPP connection to a gateway, including the steps of:

establishing a first network session between the gateway and said first network;

receiving a first real network address for the user, said first real network address assigned by said first network;

establishing a second network session between the gateway and a second network while said first network session is established;

receiving a second real network address for the user, said second real network address assigned by said second network;

receiving a packet sent by the user;

examining said packet to determine if its destination is said first network or said second network;

forwarding said packet to the first network if said packet indicates that its destination is said first network;

performing network address translation on said packet; and

forwarding said translated packet to said second network if said packet indicates that its destination is said second network.

12. The method of claim 11, further including the steps of:

assigning the user a virtual network address;

storing said virtual network address in a network address translation table in an entry corresponding to said first real network address; and

storing said virtual network address in a network address translation table in an entry corresponding to said first real network address.

13. The method of claim 12, wherein said assigning step includes the step of assigning the user a virtual network address utilizing a network address translation allocation scheme.

14. The method of claim 13, wherein said first network session and said second network session are L2TP sessions.

15. The method of claim 11, wherein said first network session and said second network session are tunneling sessions.

16. The method of claim 11, wherein said examining step further includes the steps of:

extracting a destination network address from the packet;

looking up said destination network address in a routing table;

determining that said destination is the first or second network based upon the listing for the destination network address in the routing table; and

determining that said destination is the first or second network based on a default setting if said destination network address is not listed in said routing table.

17. The method of claim **11**, wherein said performing network address translation step includes the step of applying a network address translation mapping scheme to said destination network address.

18. The method of claim **11**, wherein said performing network address translation step includes the step of looking up said destination network address in a network address translation table.

19. The method of claim **11**, further including the steps of:

receiving a second packet, said second packet sent from said first network or said second network;

performing network address translation on said second packet; and

forwarding said second packet to the user.

20. A method for network communications in a system having a user with a PPP connection to a gateway, including the steps of:

receiving a first PPP connection request from the user;

negotiating LCP options between the user and a first network;

establishing a first PPP session between the gateway and said first network;

receiving a first real network address for the user, said first real network address assigned by said first network;

receiving a second PPP connection request from the user;

negotiating LCP options between the user and a second network;

establishing a second PPP session between the gateway and said second network while said first PPP session is established;

receiving a second real network address for the user, said second real network address assigned by said second network;

receiving a packet sent by the user;

examining said packet to determine if its destination is said first network or said second network;

forwarding said packet to the first network if said packet indicates that its destination is said first network;

performing network address translation on said packet if said packet indicates that its destination is said second network; and

forwarding said translated packet to said second network if said packet indicates that its destination is said second network.

21. The method of claim **20**, further including the steps of:

assigning the user a virtual network address;

storing said virtual network address in a network address translation table in an entry corresponding to said first real network address; and

storing said virtual network address in a network address translation table in an entry corresponding to said first real network address.

22. The method of claim **21**, wherein said assigning step includes the step of assigning the user a virtual network address utilizing a network address translation allocation scheme.

23. The method of claim **20**, wherein said first network session and said second network session are tunneling sessions.

24. The method of claim **23**, wherein said first network session and said second network session are L2TP session.

25. The method of claim **20**, wherein said examining step further includes the steps of:

extracting a destination network address from the packet;

looking up said destination network address in a routing table;

determining that said destination is the first or second network based upon the listing for the destination network address in the routing table; and

determining that said destination is the first or second network based on a default setting if said destination network address is not listed in said routing table.

26. The method of claim **20**, wherein said performing network address translation step includes the step of applying a network address translation mapping scheme to said source network address.

27. The method of claim **20**, wherein said performing network address translation step includes the step of looking up said destination network address in a source address translation table.

28. The method of claim **20**, further including the steps of:

receiving a second packet, said second packet sent from said first network or said second network;

performing network address translation on said second packet; and

forwarding said second packet to the user.

29. A network gateway for use in a system having a user with a PPP connection to the gateway, including:

a session initiator adapted to establish a first network session between the gateway and a first network;

a network address receiver adapted to receive a first real network address for the user, said first real network address assigned by said first network;

said session initiator further establish a second network session between the gateway and a second network while said first network session is established; and

said network address receiver is further adapted to receive a second real network address for the user, said second real network address assigned by said second network.

30. The network gateway of claim **29**, further including:

a network address allocator adapted to assign the user a virtual network address;

a NAT table storer adapted to store said virtual network address in a network address translation table in an entry corresponding to said first real network address; and

said NAT table storer further adapted to store said virtual network address in a network address translation table in an entry corresponding to said first real network address.

31. The network gateway of claim **30**, wherein said network address allocator is further adapted to assign the user a virtual network address utilizing a network address translation allocation scheme.

32. The network gateway of claim **29**, wherein said first network session and said second network session are tunneling sessions.

33. The network gateway of claim **32**, wherein said first network session and said second network session are L2TP sessions.

34. A network gateway for use in a system having a user with a PPP connection to the gateway, including:

a PPP session initiator adapted to establish a first PPP session between the gateway and a first network;

a network address receiver adapted to receive a first real network address for the user, said first real network address assigned by said first network;

said session initiator further adapted to establish a second PPP session between the gateway and a second network while said first PPP session is established; and

said network address receiver further adapted to receive a second real network address for the user, said second real network address assigned by said second network.

35. The network gateway of claim **34**, further including:

a network address allocator adapted to assign the user a virtual network address;

a NAT table storer adapted to store said virtual network address in a network address translation table in an entry corresponding to said first real network address; and

said NAT table storer is further adapted to store said virtual network address in a network address translation table in an entry corresponding to said first real network address.

36. The network gateway of claim **35**, wherein said network address allocator is further adapted to assign the user a virtual network address utilizing a network address translation allocation scheme.

37. The network gateway of claim **34**, wherein said first network session and said second network session are tunneling sessions.

38. The network gateway of claim **34**, wherein said first network session and said second network session are L2TP sessions.

39. A network gateway for use in a system having a user with a PPP connection to the gateway, including:

a session initiator adapted to establish a first network session between the gateway and a first network;

a network address receiver adapted to receive a first real network address for the user, said first real network address assigned by said first network;

said session initiator further establish a second network session between the gateway and a second network while said first network session is established;

said network address receiver further adapted to receive a second real network address for the user, said second real network address assigned by said second network;

a packet receiver adapted to receive a packet sent by said user;

a packet examiner adapted to examine said packet to determine if its destination is a first network or a second network;

a network address translator adapted to perform network address translation on said packet; and

a packet forwarder adapted to forward said translated packet to the first network or the second network, depending upon said packet's destination.

40. The network gateway of claim **39**, further including:

a network address allocator adapted to assign the user a virtual network address;

a NAT table storer adapted to store said virtual network address in a network address translation table in an entry corresponding to said first real network address; and

said NAT table storer is further adapted to store said virtual network address in a network address translation table in an entry corresponding to said first real network address.

41. The network gateway of claim **40**, wherein said network address allocator is further adapted to assign the user a virtual network address utilizing a network address translation allocation scheme.

42. The network gateway of claim **40**, wherein said network address translator is further adapted to look up said source network address in a network address translation table.

43. The network gateway of claim **39**, wherein said first network session and said second network session are tunneling sessions.

44. The network gateway of claim **43**, wherein said first network session and said second network session are L2TP sessions.

45. The network gateway of claim **39**, wherein said packet examiner further includes:

an network address extractor adapted to extract a destination network address from said packet;

a routing table searcher adapted to look up said destination network address in a routing table;

a network determiner adapted to determine that said destination is said first network or said second network based upon the listing for the destination network address in the routing table; and

said network determiner further determine that said destination is the said first network or second network based on a default setting if said destination network address is not listed in said routing table.

46. The network gateway of claim **39**, wherein said network address translator is further adapted to apply a network address translation mapping scheme to said source network address.

47. The network gateway of claim **39**, wherein said packet receiver is further adapted to receive a second packet, said second packet sent from said first network or said second network, said network address translator is further adapted to perform network address translation on said second packet, and said packet forwarder is further adapted to forward said second packet to the user.

48. A network gateway for use in a system having a user with a PPP connection to the gateway, including:

a PPP session initiator adapted to establish a first PPP session between the gateway and a first network;

a network address receiver adapted to receive a first real network address for the user, said first real network address assigned by said first network;

said session initiator further adapted to establish a second PPP session between the gateway and a second network while said first network session is established;

said network address receiver further adapted to receive a second real network address for the user, said second real network address assigned by said second network;

a packet receiver adapted to receive a packet sent by said user;

a packet examiner adapted to examine said packet to determine if its destination is a first network or a second network;

a network address translator adapted to perform network address translation on said packet; and

a packet forwarder adapted to forward said translated packet network or the second packet's destination.

49. The network gateway of claim **48**, further including:

a network address allocator adapted to assign the user a virtual network address;

a NAT table storer adapted to store said virtual network address in a network address translation table in an entry corresponding to said first real network address; and

said NAT table storer further adapted to store said virtual network address in a network address translation table in an entry corresponding to said first real network address.

50. The network gateway of claim 49, wherein said network address allocator is further adapted to assign the user a virtual network address utilizing a network address translation allocation scheme.

51. The network gateway of claim 49, wherein said network address translator is further adapted to look up said source network address in a network address translation table.

52. The network gateway of claim 48, wherein said first network session and said second network session are tunneling sessions.

53. The network gateway of claims 52, wherein said first network session and said second network session are L2TP sessions.

54. The network gateway of claim 48, wherein said packet examiner further includes:

an network address extractor adapted to extract a destination network address from said packet;

a routing table searcher adapted to look up said destination network address in a routing table;

a network determiner adapted to determine that said destination is said first network or said second network based upon the listing for the destination network address in the routing table; and

said network determiner further adapted to determine that said destination is the said first network or second network based on a default setting if said destination network address is not listed in said routing table.

55. The network gateway of claim 48, wherein said network address translator is further adapted to apply a network address translation mapping scheme to said source network address.

56. The network gateway of claim 48, wherein said packet receiver is further adapted to receive a second packet, said second packet sent from said first network or said second network, said network address translator is further adapted to perform network address translation on said second packet, and said packet forwarder is further adapted to forward said second packet to the user.

57. A program storage device readable by a machine, tangibly embodying a program of instructions executable by the machine to perform method steps for establishing multiple network connections for a user having a PPP connection to a gateway, said method steps including the steps of:

establishing a first network session between the gateway and said first network;

receiving a first real network address for the user, said first real network address assigned by said first network;

establishing a second network session between the gateway and a second network while said first network session is established; and

receiving a second real network address for the user, said second real network address assigned by said second network.

58. The program storage device of claim 57, wherein the method further includes the steps of:

assigning the user a virtual network address; and

storing said virtual network address in a network address translation table in an entry corresponding to said first real network address; and

storing said virtual network address in a network address translation table in an entry corresponding to said second real network address.

59. The program storage device of claim 58, wherein said assigning step includes the step of assigning the user a virtual network address utilizing a network address translation allocation scheme.

60. The program storage device of claim 57, wherein said first network session and said second network session are tunneling sessions.

61. The program storage device of claim 60, wherein said first network session and said second network session are L2TP sessions.

62. A program storage device readable by a machine, tangibly embodying a program of instructions executable by the machine to perform method steps for establishing multiple network connections for a user having a PPP connection to a gateway, said method steps including the steps of:

receiving a first PPP connection request from the user;

negotiating LCP options between the user and a first network;

establishing a first PPP session between the gateway and said first network;

receiving a first real network address for the user, said first real network address assigned by said first network;

receiving a PPP connection request from the user;

negotiating LCP options between the user and a second network;

establishing a second PPP session between the gateway and a second network while said first PPP session is established; and

receiving a second real network address for the user, said second real network address assigned by said second network.

63. The program storage device of claim 62, wherein the method further includes the steps of:

assigning the user a virtual network address; and

storing said virtual network address in a network address translation table in an entry corresponding to said first real network address; and

storing said virtual network address in a network address translation table in an entry corresponding to said second real network address.

64. The program storage device of claim 63, wherein said assigning step includes the step of assigning the user a virtual network address utilizing a network address translation allocation scheme.

65. The program storage device of claims 62, wherein said first network session and said second network session are tunneling sessions.

66. The program storage device of claim 65, wherein said first network session and said second network session are L2TP sessions.

67. A program storage device readable by a machine, tangibly embodying a program of instructions executable by the machine to perform method steps for establishing multiple network connections for a user having a PPP connection to a gateway, said method steps including the steps of:

establishing a first network session between the gateway and said first network;

receiving a first real network address for the user, said first real network address assigned by said first network;

establishing a second network session between the gateway and a second network while said first network session is established;

receiving a second real network address for the user, said second real network address assigned by said second network;

receiving a packet sent from the user;

examining said packet to determine if its destination is the first network or the second network;

performing network address translation on said packet; and

forwarding said translated packet to the first network or the second network, depending upon said packet's destination.

68. The program storage device of claim **67**, wherein the method further includes the steps of:

assigning the user a virtual network address; and

storing said virtual network address in a network address translation table in an entry corresponding to said first real network address; and

storing said virtual network address in a network address translation table in an entry corresponding to said second real network address.

69. The program storage device of claim **68**, wherein said assigning step includes the step of assigning the user a virtual network address utilizing a network address translation allocation scheme.

70. The program storage device of claim **68**, wherein said performing network address translation step includes the step of looking up said source network address in a network address translation table.

71. The program storage device of claim **67**, wherein said first network session and said second network session are tunneling sessions.

72. The program storage device of claim **71**, wherein said first network session and said second network session are L2TP sessions.

73. The program storage device of claim **67**, wherein said examining step further includes the steps of:

extracting a destination network address from the packet;

looking up said destination network address in a routing table;

determining that said destination is the first or second network based upon the listing for the destination network address in the routing table; and

determining that said destination is the first or second network based on a default setting if said destination network address is not listed in said routing table.

74. The program storage device of claim **67**, wherein said performing network address translation step includes the step of applying a network address translation mapping scheme to said source network address.

75. The program storage device of claim **67**, wherein the method further includes the steps of:

receiving a second packet, said second packet sent from said first network or said second network;

performing network address translation on said second packet; and

forwarding said second packet to the user.

76. A program storage device readable by a machine, tangibly embodying a program of instructions executable by the machine to perform method steps for establishing multiple network connections for a user having a PPP connection to a gateway, said method steps including the steps of:

receiving a first PPP connection request from the user;

negotiating LCP options between the user and a first network;

establishing a first PPP session between the gateway and said first network;

receiving a first real network address for the user, said first real network address assigned by said first network;

receiving a second PPP connection request from the user;

negotiating LCP options between the user and said second network;

establishing a second PPP session between the gateway and a second network while said first PPP session is established;

receiving a second real network address for the user, said second real network address assigned by said second network;

receiving a packet sent from the user;

examining said packet to determine if its destination is the first network or the second network;

performing network address translation on said packet; and

forwarding said translated packet to the first network or the second network, depending upon said packet's destination.

77. The program storage device of claim **76**, wherein the method further includes the steps of:

assigning the user a virtual network address; and

storing said virtual network address in a network address translation table in an entry corresponding to said first real network address; and

storing said virtual network address in a network address translation table in an entry corresponding to said second real network address.

78. The method of claim **77**, wherein said assigning step includes the step of assigning the user a virtual network address utilizing a network address translation allocation scheme.

79. The program storage device of claim **77**, wherein said performing network address translation step includes the step of looking up said source network address in a network address translation table.

80. The program storage device of claim **76**, wherein said first network session and said second network session are tunneling sessions.

81. The program storage device of claim **80**, wherein said first network session and said second network session are L2TP sessions.

82. The program storage device of claim **76**, wherein said examining step further includes the steps of:

extracting a destination network address from the packet;

looking up said destination network address in a routing table;

determining that said destination is the first or second network based upon the listing for the destination network address in the routing table; and

determining that said destination is the first or second network based on a default setting if said destination network address is not listed in said routing table.

83. The program storage device of claim **76**, wherein said performing network address translation step includes the step of applying a network address translation mapping scheme to said source network address.

84. The program storage device of claims **76**, wherein the method further includes the steps of:

receiving a second packet, said second packet sent from said first network or said second network;

performing network address translation on said second packet; and

forwarding said second packet to the user.

85. A network gateway for network communications in a system having a user with a PPP connection to the gateway, including:

means for establishing a first network session between the gateway and said first network;

means for receiving a first real network address for the user, said first real network address assigned by said first network;

means for establishing a second network session between the gateway and a second network while said first network session is established;

means for receiving a second real network address for the user, said second real network address assigned by said second network;

means for receiving a packet sent by the user;

means for examining said packet to determine if its destination is said first network or said second network;

means for forwarding said packet to the first network if said packet indicates that its destination is said first network;

means for performing network address translation on said packet; and

means for forwarding said translated packet to said second network if said packet indicates that its destination is said second network.

86. The network gateway of claim **85**, further including:

means for assigning the user a virtual network address; and

means for storing said virtual network address in a network address translation table in an entry corresponding to said first real network address; and

means for storing said virtual network address in a network address translation table in an entry corresponding to said second real network address.

87. The network gateway of claim **86**, wherein said means for assigning includes means for assigning the user a virtual network address utilizing a network address translation allocation scheme.

88. The network gateway of claim **86**, wherein said performing network address translation means includes means for looking up said source network address in a network address translation table.

89. The network gateway of claim **85**, wherein said first network session and said second network session are tunneling sessions.

90. The network gateway of claim **89**, wherein said first network session and said second network session are L2TP sessions.

91. The network gateway of claim **85**, wherein said examining means further includes:

means for extracting a destination network address from the packet;

means for looking up said destination network address in a routing table;

means for determining that said destination is the first or second network based upon the listing for the destination network address in the routing table; and

means for determining that said destination is the first or second network based on a default setting if said destination network address is not listed in said routing table.

92. The network gateway of claim **85**, wherein said performing network address translation means includes means for applying a network address translation mapping scheme to said source network address.

93. The network gateway of claim **85**, further includes:

means for receiving a second packet, said second packet sent from said first network or said second network;

means for performing network address translation on said second packet; and means for forwarding said second packet to the user.

* * * * *

UNITED STATES PATENT AND TRADEMARK OFFICE

CERTIFICATE OF CORRECTION

PATENT NO. : 6,490,289 B1
DATED : December 3, 2002
INVENTOR(S) : Shujin Zhang et al.

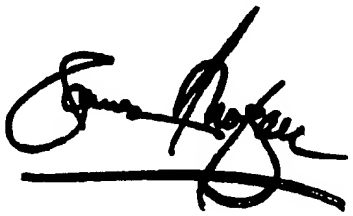
It is certified that error appears in the above-identified patent and that said Letters Patent is hereby corrected as shown below:

Column 6,
Line 20, replace "2204," with -- 204 --.

Column 12,
Line 57, replace "network or the second packet's destination." with
-- to the first network or the second network, depending upon said packet's destination. --.

Signed and Sealed this

Nineteenth Day of August, 2003



JAMES E. ROGAN
Director of the United States Patent and Trademark Office